



UNIVERSITI PUTRA MALAYSIA

**EFFECTS OF THE USE OF CALCULATORS, THE POLYA
HEURISTIC AND WORKED EXAMPLES ON PERFORMANCE IN
LEARNING MATHEMATICS FROM A COGNITIVE LOAD
PERSPECTIVE**

LAWRENCE ALOYSIUS AERIA.

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By

LAWRENCE ALOYSIUS AERIA

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in Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

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fulfilment of the requirement for the degree of Doctor of Philosophy

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December 2004

Chairman: Associate Professor Rohani Ahmad Tarmizi, Ph.D.

Faculty: Educational Studies

Cognitive load theory holds that if an instructional format reduces extraneous cognitive load and/or increases germane cognitive load during learning, as compared to another instructional format, then it will be more efficient in promoting learning, provided that the total cognitive load does not exceed the total mental resources. Based on this premise, a series of four experiments was conducted to investigate the use of calculators, the Polya heuristic and worked examples in an attempt to generate an alternative instructional format that is more instructionally efficient than the conventional one to teach Percentage to Form 1 students. It was hypothesized that the use of calculators and the use of worked examples can reduce cognitive load during learning and lead to better learning performance while the use of the Polya heuristic increases cognitive load and reduces learning performance. The results from the experiments

indicated that the use of calculators and worked examples reduced cognitive load and led to better learning performance but the use of the Polya heuristic produced zero effects. Based on the results from the experiments, an alternative instructional format, called the calcworked instructional format, that incorporated the use of calculators and the use of partial completion worked examples was generated. The calcworked instructional format was compared with the conventional instructional format and was found to be more instructionally efficient.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**KESAN PENGGUNAAN KALKULATOR, HEURISTIK POLYA
DAN CONTOH PENYELESAIAN TERHADAP PRESTASI
DALAM PEMBELAJARAN MATEMATIK DARIPADA
SATU PERSPEKTIF BEBANAN KOGNITIF**

Oleh

LAWRENCE ALOYSIUS AERIA

Disember 2004

Pengerusi: Profesor Madya Rohani Ahmad Tarmizi, Ph.D.

Fakulti: Pengajian Pendidikan

Teori bebanan kognitif menegaskan bahawa jika sesuatu format pengajaran mengurangkan bebanan kognitif *ekstraneous* dan/atau menambahkan bebanan kognitif *germane* semasa pembelajaran, berbanding dengan sesuatu format pengajaran yang lain, maka format pengajaran tersebut akan lebih cekap dalam menggalakkan pembelajaran selagi jumlah bebanan kognitif tidak melebihi jumlah sumber mental. Berdasarkan pernyataan ini, satu siri yang mengandungi empat eksperimen telah dijalankan untuk mengkaji penggunaan kalkulator, heuristik Polya dan contoh penyelesaian supaya dapat diwujudkan satu format pengajaran alternatif yang lebih cekap berbanding format pengajaran konvensional, untuk mengajar tajuk Peratusan kepada pelajar Tingkatan 1. Hipotesis telah dibuat bahawa penggunaan kalkulator dan contoh penyelesaian dapat mengurangkan bebanan kognitif semasa

pembelajaran dan meningkatkan prestasi pembelajaran manakala penggunaan heuristik Polya akan menambahkan bebanan kognitif dan mengurangkan prestasi pembelajaran. Keputusan eksperimen menunjukkan bahawa penggunaan kalkulator dan contoh penyelesaian dapat mengurangkan bebanan kognitif dan meningkatkan prestasi pembelajaran tetapi penggunaan heuristik Polya menghasilkan kesan sifar. Berdasarkan keputusan eksperimen-eksperimen tersebut, satu format pengajaran alternatif, dinamakan format pengajaran *calcworked*, yang menggabungkan penggunaan kalkulator dan contoh penyelesaian separa lengkap telah diwujudkan. Jika dibandingkan dengan format pengajaran konvensional, format pengajaran *calcworked* didapati lebih cekap.

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I certify that an Examination Committee met on 15th December 2004 to conduct the final examination of Lawrence Aloysius Aeria on his Doctor of Philosophy thesis entitled "Effects of the Use of Calculators, the Polya Heuristic and Worked Examples on Performance in Learning Mathematics from a Cognitive Load Perspective" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Othman Dato' Hj. Mohamed, Ph.D.

Professor
Faculty of Educational Studies
Universiti Putra Malaysia
(Chairman)

Aida Suraya Haji Md. Yunus, Ph.D.

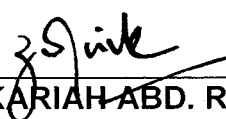
Associate Professor
Faculty of Educational Studies
Universiti Putra Malaysia
(Member)

Habibah Elias, Ph.D.

Professor
Faculty of Educational Studies
Universiti Putra Malaysia
(Member)

John Sweller, Ph.D.

Professor
Faculty of Education
University of New South Wales
(Independent Examiner)


ZAKARIAH ABD. RASHID, Ph.D.
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

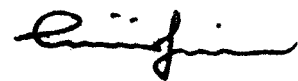
Date: 17 MAR 2005

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

Rohani Ahmad Tarmizi, Ph.D.
Associate Professor
Faculty of Educational Studies
Universiti Putra Malaysia
(Chairperson)

Kamariah Hj. Abu Bakar, Ph.D.
Professor
Faculty of Educational Studies
Universiti Putra Malaysia
(Member)

Turiman Hj. Suandi, Ph.D.
Professor
Faculty of Educational Studies
Universiti Putra Malaysia
(Member)

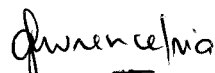


AINI IDERIS, Ph.D.
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 14 APR 2005

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



LAWRENCE ALOYSIUS AERIA

Date: 22nd April 2004

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CHAPTER 1

INTRODUCTION

Background of the Study

Introduction

In the last few decades, the mathematical community has struggled to define what mathematics is and what mathematical thinking means. One possible reason for this is the growing role of mathematics, science and technology in modern life (Organization of Economic Co-operation and Development, 2004). Consequently, there have been numerous changes made to the mathematics curriculum used in schools and institutions of higher learning.

The events in the United States typify the situation. According to Schoenfeld (1992), in 1957 when the Russians launched their space satellite *Sputnik*, it galvanized American educators, scientists and mathematicians to restructure the curriculum in line with their notion of what mathematics and mathematical thinking should be. Thus evolved *The New Maths*. When it was discovered that this new curriculum was not working, the pendulum swung to the other end and the *back-to-basics* movement grew in popularity. This too was eventually deemed to be inadequate as students were found wanting on measures of thinking. The dismal performance of the *back-to-basics* movement led